

Name: Key

Chemistry 129 Spring 2017

General Chemistry

Second Examination:

Periodic table is provided.

You may use a calculator.

Show all your work!

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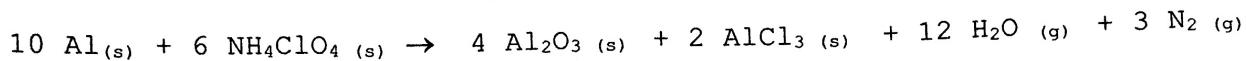
page 5: _____/15

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Bonus: _____/2

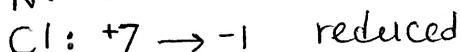
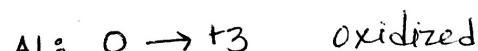
Total: _____/100

1. (12pts) Consider the following reaction:



Determine the oxidation number of each element. Which element is reduced and which oxidized? Identify the reducing agent and the oxidizing agent.

Reactants		Products	
Element	Oxidation	Element	Oxidation
Al	0	Al (in Al_2O_3)	+3
N	-3	Al (in AlCl_3)	+3
H	+1	N	0
Cl	+7	H	+1
O	-2	Cl	-1
		O (in Al_2O_3)	-2
		O (in H_2O)	-2

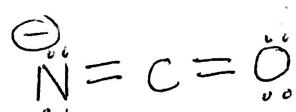


2. (10pts) The cyanate ion (NCO^-) has three possible Lewis structures.

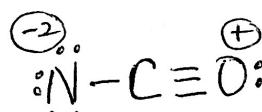
- (a) Draw these three Lewis structures, and assign formal charges to the atoms in each structure.



$$\begin{array}{rrr} 5 & 4 & 6 \\ -2 & -0 & -6 \\ -3 & -4 & -1 \\ \hline 0 & 0 & -1 \end{array}$$

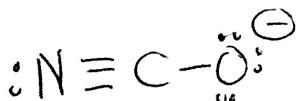


$$\begin{array}{rrr} 5 & 4 & 6 \\ -4 & -0 & -4 \\ -2 & -4 & -2 \\ \hline -1 & 0 & 0 \end{array}$$



$$\begin{array}{rrr} 5 & 4 & 6 \\ -6 & -0 & -2 \\ -1 & -4 & -3 \\ \hline -2 & 0 & +1 \end{array}$$

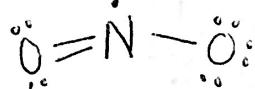
- (b) Which Lewis structure is the preferred one? Why?



3. (18pts) Consider the following molecules: NO_2 , IF_5 , ClF_3 .

(i) Draw their Lewis structure, (ii) Determine the electron group and molecular geometries, (iii) Is the molecule polar or nonpolar?

(a) NO_2



Electron Group Geometry:

trigonal planar

Molecular Geometry:

bent

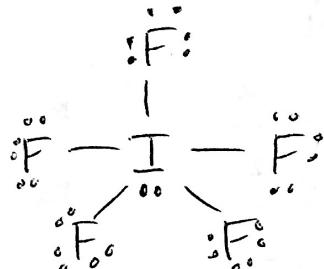
Polar or Nonpolar?:

polar

Hybridization of Central Atom:

sp^2

(b) IF_5



Electron Group Geometry:

Octahedral

Molecular Geometry:

square pyramidal

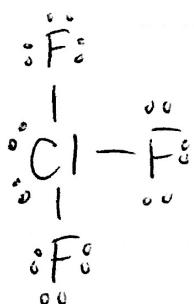
Polar or Nonpolar?:

polar

Hybridization of Central Atom:

sp^3d^2

(c) ClF_3



Electron Group Geometry:

trigonal bipyramidal

Molecular Geometry:

T-shaped

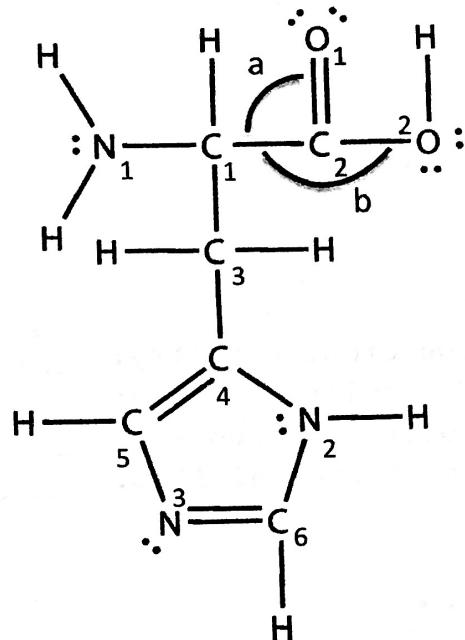
Polar or Nonpolar?:

polar

Hybridization of Central Atom:

sp^3d

4. (13pts) (a) What are the hybridizations of the **six carbon**, the **two oxygen**, and **three nitrogen** atoms?



$$C_1: \underline{SP^3}$$

$$C_2: \underline{SP^2}$$

$$C_3: \underline{SP^3}$$

$$C_4: \underline{SP^2}$$

$$C_5: \underline{SP^2}$$

$$C_6: \underline{SP^2}$$

$$O_1: \underline{SP^2}$$

$$O_2: \underline{SP^3}$$

$$N_1: \underline{SP^3}$$

$$N_2: \underline{SP^3}$$

$$N_3: \underline{SP^2}$$

How many sigma bonds and pi bonds does the molecule have?

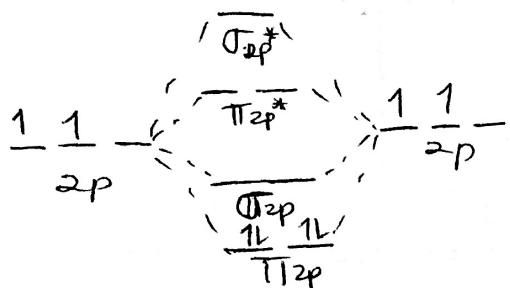
20 sigma bonds 3 pi bonds

- (b) Which angle is smaller a or b? Explain.

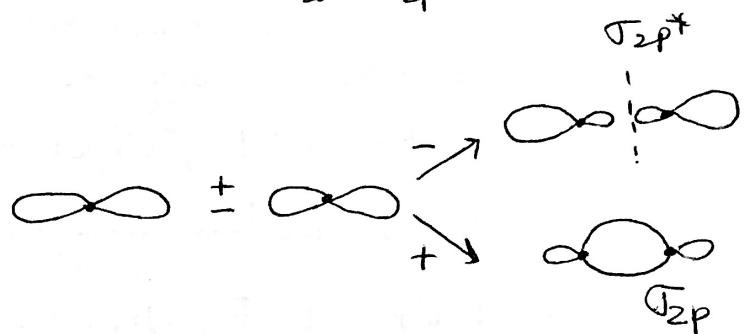
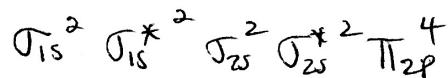
Angle b is smaller. Double bonds exert more repulsion than single bonds which result in angle a being greater than 120° .

5. (17pts) Using the molecular orbital energy diagram given below (for **ALL** electrons):

a. (8 pts) **Complete** the molecular orbital energy-level diagram for C_2 and write its electron configuration. **Label** all the atomic orbitals and molecular orbitals. **Sketch** the shape of the σ_{2p} and σ_{2p}^* molecular orbitals. C_2 molecule



Electron Configuration:



C_{atom} C_{atom}

b. (3 pts) Determine the bond order of C_2 . Is C_2 paramagnetic or diamagnetic? Why?

$$B.O. = \frac{1}{2}(8 - 4) = 2$$

Diamagnetic. All its electrons are paired up.

c. (6 pts.) If two electrons are added from C_2 to form C_2^{2-} , how many unpaired electrons would C_2^{2-} have? Calculate the bond order of C_2^{2-} . Which would you expect to have a stronger bond, C_2 or C_2^{2-} ? Longer bond? Why?

No unpaired electrons

$$C_2^{2-} \Rightarrow B.O. = \frac{1}{2}(10 - 4) = 3$$

$C_2^{2-} \Rightarrow$ stronger bond

$C_2 \Rightarrow$ longer bond

6. (15pts) (a) When NaF dissolves in water, the main force of attraction that exists between F^- and H_2O is called ion-dipole forces.

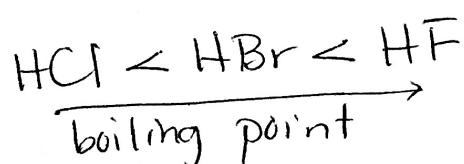
(b) Hydrogen sulfide (H_2S) is a gas at room temperature. What is the major attractive force that exists among different hydrogen sulfide molecules in the gas?
dipole-dipole forces.

(c) Identify intermolecular forces present in each of the following and arrange them in order of **increasing** boiling point: **HCl**, **HF**, and **HBr**. Explain.

HCl: LDF, dipole-dipole

HF: LDF, H bonding

HBr: LDF, dipole-dipole

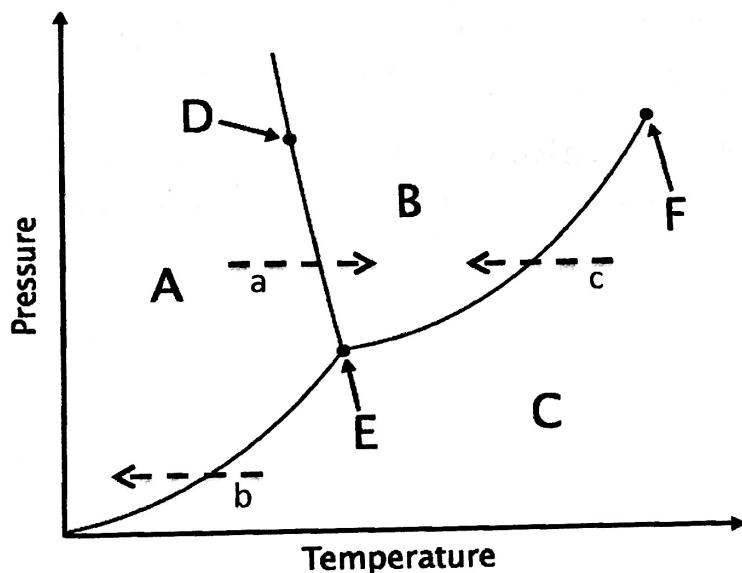


As we move down group **VIIA**, the polarities of the molecules decrease slightly and the masses of molecules increase significantly. For HCl, HBr and HI, the increase in mass results in stronger dispersion forces and dominates the increasingly weaker dipole-dipole. HF will have the higher boiling point due to the stronger Hydrogen bonds.

(d) Which molecule would you expect to be more soluble in water, CH_2Cl_2 or CCl_4 ? Why?

CH_2Cl_2 is more soluble in water

7. (15pts) (i) The phase diagram of a hypothetical substance is shown in the following figure. Identify the phase(s) present at points A through F.



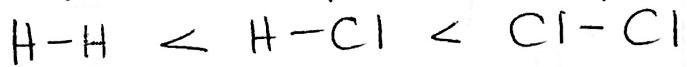
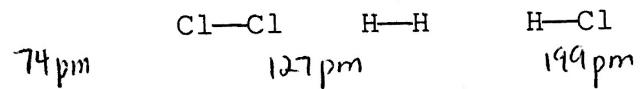
- A: Solid
- B: Liquid
- C: Gas
- D: Solid & Liquid
- E: Solid, Liquid & Gas
- F: Supercritical Fluid (beyond this point)

(ii) Name the phase change shown by the dashed arrows. Is the process endothermic or exothermic?

- fusion - endothermic
- deposition - exothermic
- condensation - exothermic

Bonus: (2 pts)

Arrange the following in order of increasing length. Explain.



As the size of the atoms increase,
so does the distance between them.